AD-3: Redesign Terminal Airspace and Routes

Terminal airspace and route redesign.

Background

Current congestion in transition and en route airspace often limits the ability to get departing aircraft off the ground. Similarly, airspace congestion can limit arrivals, even if runway capacity is available. In many terminal areas today, arrival and departure procedures overlap either because they were designed for lower volumes and staffing, or because they are based on ground-based navigation. These routes are strongly interdependent. Many airports have common departure fixes or arrival fixes that must service a variety of aircraft types with different performance characteristics. By requiring departures to navigate or funnel through common departure fixes, the throughput rates at the airports involved must be suppressed. Similar problems exist with arrivals.

Ops Change Description

The operational change described here includes three concepts to reduce interdependencies between arrival and departure flows:

- AD-3.1: Use existing airspace structures and apply traffic management strategies to depart aircraft through congested transition airspace. Capping and tunneling techniques are included as part of the National Airspace Redesign System Choke Points program.

- AD-3.2: Restructure arrival and departure routes to be independent of navigation aids, using existing RNAV technologies RNAV route development is a primary function of Air Traffic procedural development and a foundation element of the National Airspace Redesign.

- AD-3.3: Optimization and redesign of the terminal area airspace and operations. Terminal optimization and redesign projects are a key component of the National Airspace Redesign.

Terminal airspace optimization and redesign is a foundation component of the National Airspace redesign. Terminal airspace optimization efforts are ongoing initiatives to ensure the airspace design and use is effective for transitioning aircraft to and from the associated airport or airports. Terminal airspace redesign is a major undertaking to develop a structure that takes full advantage of evolving technologies and aircraft capabilities. This redesign will provide flexibility for system users to efficiently transition into and out of terminal airspace while making maximum use of airspace and airport capacity.

Where volume has increased and the current airspace structure is the limiting factor, redesigning these procedures, including the addition of RNAV procedures, will allow for more efficient use of the constrained terminal airspace. Area Navigation, or RNAV, is a method of navigation that permits aircraft operations on any desired course within the coverage of station referenced navigation signals or within the limits of self contained system capability or combination of these. The acronym "RNAV" has been adopted by industry as an umbrella term that encompasses any procedure or operation that utilizes point to point navigation, from ground or

air-based/space-based sources. The expectation is that in the future, this will evolve away from dependence on ground-based navigation resources. This is manifested through use of on-board avionics and flight management systems (FMS).

RNAV procedures in terminal airspace can reduce complexity and increase efficiency in the near and mid-term. When designed collaboratively, the procedures require minimal vectoring and/or communications between the flight crews and the ATC controllers. These procedures can be used to reduce voice communications associated with speed and altitude instructions, freeing up more controller time. The procedure, when implemented, describes a flight path that includes position, altitude, and time.

Benefits, Performance and Metrics

- Increase on-time departures.

- Increase airport capacity utilization effectiveness.

- Improved predictability

A procedure is predictable if the time to fly the procedure and the distance flown each time the procedure is executed is close to the same. Some ARTS track data for the CLT NALEY departure procedure from Sept 8 and 9, 2000 was used to compute average flying times and distances and their dispersions. This data set provided 14 flights that flew the departure procedure and during this same period there were 37 flights that did not fly the procedure. These flights were aircraft departing to the same departure fix as for NALEY, so it was appropriate to compare the flying times and distances of these flights with the RNAV flights. CLT facility had identified which aircraft were equipped and flew the procedure. Table AD-3.1 summarizes the results of flying times and distances for this set of aircraft. For this data set, the average flying time and distance was the same for the RNAV and non-RNAV aircraft. However, the dispersion in the flying times and distances differed. The dispersion in the flying times on the non-RNAV aircraft was 3 times larger than for the RNAV and the dispersion in the flying distances was over twice as large as for the RNAV.

Table AD-3.1 CLT NALEY Departures

Sept. 7 and 8	RNAV Flights (14)	Non-RNAV Flights (37)
Average Flying Time (min)	6.6	6.6
Standard Deviation (min)	.1	.3
Average Flying Distance (nm)	31.4	31.4
Standard Deviation (nm)	.4	.9

- Reduced excess gate times (duration and/or occurrence).

- Reduction in en route delay.

- Arrival rates percent effectiveness increase for airports where the en route transition sectors suffer high frequency congestion (e.g., ATL northeast arrivals).

- Allows controller to deliver the aircraft with reduced restrictions and vectoring.

- Workload reductions so controllers can reduce restrictions to aircraft and close up spacing to the separation standard.

- Assuming that the use of RNAV is the primary flight practice for arrivals, the percent of control transmissions can be reduced per day by the estimates[1] in the following tables. The reduction in number of air/ground communications will reduce controller and pilot workload, as well as mitigating the advent of frequency congestion issues in the future. Overall effect is to maintain maximum utilization of available runway capacity.

Table AD-3.2 Percent Reduction In Control Transmissions

Airport	Percent	Airport	Percent	Airport	Percent	Airport	Percent	Airport	Percent
BOS	29	ATL	32	DFW	33	LAX	27	MSP	23
EWR	38	MIA	28	STL	17	PHX	33	OAK	19
ORD	42	PHL	37	LAS	37	DEN	37	DTW	20

Following September 11, ETMS flight plan data was used to compute the percent RNAV equipage at the top 25 airports by operations. The before timeframe data consisted of 8/11/01-9/6/01 and the after timeframe data consisted of 10/12/01-11/18/01. The 30 days following 9/11/01 were considered a transition period and were excluded from the analysis. It is reasonable to assume that the before RNAV equipage levels matched the levels used to produce the numbers in Table AD-3.3 above. Table AD-3.4 summarizes the percent change in RNAV equipage for these 25 airports. Note that the airports are not ordered by number of operations in the table.

Table AD-3.3 Percent Change in RNAV Equipage Post-September 11, 2001

Airport	Percent Change	Airport	Percent Change	Airport	Percent Change	Airport	Percent Change	Airport	Percent Change
BOS	+8	ATL	+3	DFW	0	LAX	0	MSP	+4
EWR	+4	MIA	+6	STL	+5	PHX	0	OAK	0
ORD	+5	PHL	+3	LAS	-2	DEN	+4	DTW	+5
CVG	+6	PIT	+8	IAD	+2	CLT	+2	SEA	+1
SFO	-1	SNA	-2	SBF	0	IAH	+8	MEM	+4

This table illustrates that the average RNAV equipage at these airports has increased approximately 3%. These changes in were used to update TableAD-3.3 and are given in Table AD-3.4 below:

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[1] Estimates are generated based on real world experience of actual transmission reductions at several current locations. Estimates are based on levels of equipage and estimates of transmissions per flight in the terminal area at these locations, based on data available pre-September 11. Estimates are for airport specific populations. Revalidation of these estimates is currently underway.

Table AD-3.4 Percent Reduction In Control Transmissions Post-September 11, 2001

Airport	Percent	Airport	Percent	Airport	Percent	Airport	Percent	Airport	Percent
BOS	36	ATL	35	DFW	33	LAX	27	MSP	28
EWR	39	MIA	31	STL	22	PHX	33	OAK	19
ORD	46	PHL	39	LAS	33	DEN	40	DTW	24

AD-3.1 Expedited Departure Routes

Scope and Applicability

Two traffic management techniques are being used in the near- and mid-term to expedite departures into congested transition airspace:

- LAADR (Low Altitude Alternate Departure Routes) is a program that allows aircraft to take off, climb to a lower altitude and then achieve their desired/requested altitude later in the flight. Aircraft can proceed to desired altitude as soon as controller clears them. A Letter of Agreement (LOA) is needed between participating facilities along with agreements from participating airlines. This program is facilitated by the ATCSCC. Two LAADR Memoranda of Understanding (MOUs) exist: STL and PHL.

- As part of National Airspace Redesign Choke Points activities, TAAP (Tactical Altitude Assignment Program) is being explored as a viable method to get traffic operating in less congested altitudes, though perhaps these altitudes are less optimal in terms of fuel usage. TAAP is expected to reduce en route congestion and has potential benefits of getting aircraft off the ground sooner, although filing TAAP does not guarantee that the flight will depart sooner. TAAP is voluntary for airline participants (they must file TAAP routes) and involves flying at lower altitudes for shorter length flights. Flights that operate under TAAP are expected to fly at the lower altitudes for the whole length of the flight, and neither the pilot nor controller is supposed to climb the aircraft for efficiency purposes. Routes, between over 100 city pairs, within eight ARTCCs in the Great Lakes corridor, Northeast, and Mid-Atlantic have been identified and agreed upon for TAAP.

Key Decisions

- None identified.

**Key Risks**

- None identified.

Status of Key Milestones

- TAAP and LAADR efforts are complete. The TAAP evaluation (flights between 300 city pairs at lower altitudes and out of busy high altitude sectors) was initiated on April 22, 2001 and completed on June 20, 2001. The results of the evaluation concluded that TAAP as a national initiative would not be as effective as planned. In place of TAAP, Low Altitude Initiatives (using the same principles of TAAP) have been implemented on a local facility level. LAADR continues to be used when applicable at sites with MOUs.

AD-3.2 Routes Independent from Navigation Aids
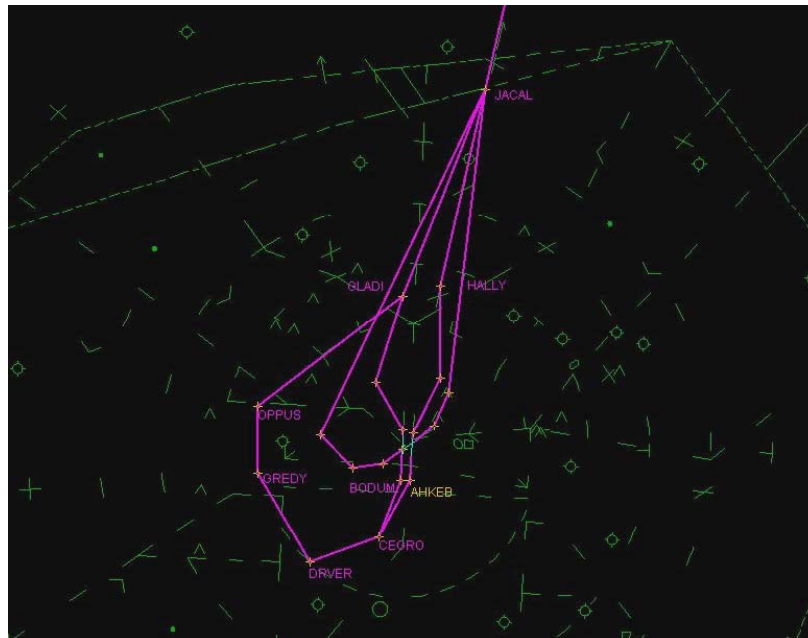
Scope and Applicability

RNAV allows for the creation of arrival and departure routes (specifically, allowing multiple entry to existing and STAR and multiple exits from Departure Procedures (DPs)) that are independent of present fixes and navigation aids. Airports with complex, multiple runway systems, or with shared or congested departure fixes benefit the most through segregating departures and providing additional routings to reduce in-trail separation increases during climb. Participation and benefits are subject to aircraft equipage levels, pilot/controller education. Radar is required for RNAV operations below FL450 (order 7110.65 5-5-1).

Design, evaluation and implementation of RNAV arrival and departure routes is ongoing across the United States. Current implementation plans include:

- In the near-term, overlay RNAV routes are being developed at EWR, PHL, JFK, CLT, IAH, LAS, and PHX.

- For the mid-term (through FY04), over 100 overlay and non-overlay routes are planned for these and additional sites, including all of the 31 benchmarked airports (STL, EWR, IAD, JFK, PHL, DCA, BWI, LGA, PIT, CVG, DTW, ORD, MSP, BOS, DEN, SEA, SLC, ATL, CLT, MCO, MEM, MIA, TPA, DFW, IAH, LAS, LAX, SFO, SNA, HNL, PHX).

- In the longer-term, RNAV with speed control will be used to support minimal spacing of aircraft on arrival. The controller maintains constant minimum spacing only between back-to-back pairs of RNAV arrivals (both must be equipped to tighten up spacing) through clearances for altitude and speed control procedures. RNAV arrival routes will not change requirements for final approach.

Key Decisions

- Identify and ensure user equipage to deliver desired benefits.

- Manufacturers and users must complete avionics certification for FMC – Required Navigational Performance (RNP), ARINC 424 (for new types).

- Pilot and controller training must be completed. Flight Crew Education includes FMC proficiency, phraseology, and ATC procedures.

Key Risks

- Environmental assessment for new routes and procedures. The implementation timeframe for these projects could increase significantly depending on the level of environmental assessment required by the proposed change.

- Segregated routes based on equipage may penalize non-equipped users. Rulemaking may be required. AOPA has indicated possible acceptance of RNAV equipage being necessary to access major congested airports during specific, limited times of day, but they must maintain access to key GA airports (e.g., Teterboro) located in close proximity to potential RNAV mandated airports.

- Systems that must be in place or may cause risks in delivery include Flight Management Computers (FMC), ATC Host/ARTS automation adaptation and display of RNAV status, and STARS adaptation and display of RNAV status.

Status of Key Milestones

- Over two dozen RNAV procedures (STARs, DPs) have been implemented at sites including BOS, CLT, DFW, EWR, IAD, IAH, JFK, LAS, PHL, PHX, and SEA.
- The number of revenue flights at PHL, EWR, JFK, and CLT is over 72,400 as of 12/01.

AD-3.3 Redesign Terminal Airspace
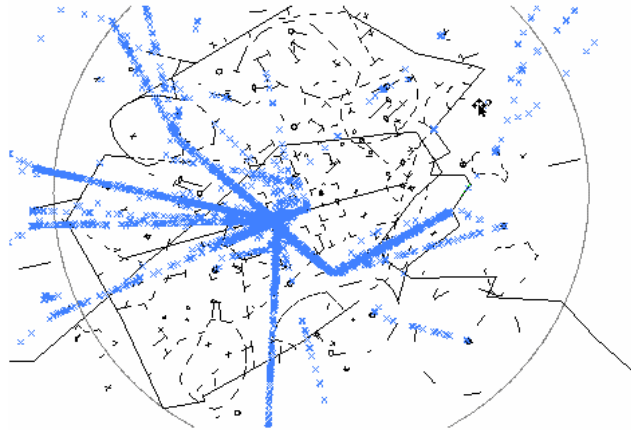
Improved Terminal Airspace Structure

Scope and Applicability

Terminal airspace optimization (mid-term) and redesign (long-term) projects are ongoing across the United States. Efforts are planned for all major metropolitan areas and congested terminal areas servicing key airports. These include:

- Mid- and long-term, large-scale redesign efforts are underway in Anchorage, St. Louis, Omaha, New York, Philadelphia, Potomac, Cleveland, Minneapolis, Detroit, Chicago, Bradley, Seattle, Portland, Denver, Cincinnati, Orlando, Charlotte, Houston, Santa Barbara, San Diego, Phoenix, Los Angeles, Las Vegas, Honolulu, and San Francisco. These redesign projects include expansion of terminal airspace (see AD-5), RNAV-base routes (see AD-3.2), arrival and departure corridors, and expanded use of terminal holding. Establishment of arrival reservoirs in the terminal airspace will allow for maximum use of runway capacity.

- Implementation for NY/NJ/PHL Redesign is planned for 2005/2006 and Potomac is planned for 2003. Alternative designs for NY/NJ/PHL and Potomac include optimization using existing infrastructure (tweaking of the current system) and redesign from a "clean-sheet." Redesigned arrival and departure routes will likely be defined as RNAV-based, not dependent on current ground aids. Design concepts include high downwind segments for arrival aircraft, unrestricted departure climbs, fanned departure headings, and VFR flyway corridors. As part of the Choke Points Action Plan, the Yardley-Robbinsville Flip-flop will provide efficiency improvements in the near term. This effort, scheduled for implementation in December 2001, will add four terminal sectors and adjust flows into the New York metropolitan area from the south.

Key Decisions

- None identified.

Key Risks

- Several infrastructure adjustments will be needed to support new sectors, including availability of building space, ATC automation, controller position equipment, and additional frequencies. Lack of availability of these systems may negatively impact the ability to transition to new sectorization or to implement additional sectors. Limitations of the current systems, specifically the HOST computer, will limit potential efficiency of some of the proposed airspace changes.

- Environmental assessment for new routes and adjusted traffic flows. The implementation timeframe for these projects could increase significantly depending on the level of environmental assessment required by the proposed change.

Status of Key Milestones

- LAS Four Corner Post Airspace Redesign was implemented in late 2001. The PHX Northwest 2000 Redesign is awaiting completion of the environmental process (, thus delaying implementation until 2002.